
Assessing the Downstream Impacts of Soil Sedimentation Caused by Small-Scale Alluvial Mining in Atamo, Central Bougainville

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Abstract: The sedimentation of soils resulting from small-scale alluvial gold mining poses major environmental and socio-economic problems for the communities concerned. This study examines the extent and consequences of soil erosion caused by mountain gold mining in the Atamo area of Central Bougainville, Papua New Guinea. Using qualitative methods, including field surveys, interviews with local communities, the study documents sediment accumulation in river basins, which has disrupted natural water flows, damaged infrastructure, and altered aquatic ecosystems. The issue is further exacerbated by the presence of climate change, where irregular and extreme rainfall events accelerate soil erosion and sediment transport from mining sites into waterways. Key findings show that sediment deposition has resulted in the diversion of rivers, road deterioration, and a deterioration of water quality for human consumption. The study also highlights the lack of awareness among miners about sediment management and the absence of formal mitigation strategies. The report concludes that soil sedimentation is a threat to environmental sustainability and hinders the livelihood and mobility of the communities concerned. The document recommends the introduction of effective erosion control measures, reforestation, and regulatory frameworks to manage mining practices and protect the ecosystems downstream.

Keywords: Soil sedimentation, alluvial mining, environmental degradation, water flow disruption, Atamo, Bougainville, small-scale mining, river ecosystems

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1. INTRODUCTION

Small-scale alluvial gold mining, a significant economic activity in Atamo, Bougainville, Papua New Guinea (PNG), poses major environmental and socio-economic challenges, particularly due to soil sedimentation. This activity is prevalent across many developing nations, serving as a vital livelihood source but often incurring substantial geo-environmental and socio-economic risks (Frontiers, 2025; IIED, 2004). In 2001, around 80,000 - 100,000 miners were engaged to alluvial mining producing 4.0 tons annually at the value of PGK100m and about 90% of these miners were categorized as grassroots (Susapu & Crispin, 2001). Small-scale mining has become a prevalent economic activity across various provinces in PNG over the past two decades. This sector has attracted both positive and negative criticisms, with reports highlighting its significance in local economy as well as its

adverse impacts on communities and the environment.

A study conducted by Suwamaru in 2019 discussed numerous challenges faced by local miners in the Autonomous Region of Bougainville (AROB), encompassing issues related to education, economic factors, and other livelihood impacts. Most studies conducted in other fields, particularly those assessing socio-economic settings, also identified alluvial mining activities as an alternative source of income, even for communities primarily engaged in agricultural activities such as cocoa and coconut farming.

This study is conducted specifically to understand how soil sedimentation, a direct consequence of upstream mining activities, has been profoundly affecting downstream communities and other non-miners living nearby as shown in figure 1 below. It aims to shed light on the cascading environmental and socio-economic challenges faced by these vulnerable populations due to altered river systems and compromised natural resources.



Figure1. Alluvial mining. A new livelihood activity in the Atomo community

1.1 Research Aim

To examine the extent and consequences of soil erosion caused by mountain gold mining in the Atamo area of Central Bougainville, Papua New Guinea.

1.2 Research Objective

To provide a detailed assessment of how soil sedimentation resulting from small-scale alluvial gold mining in the Atamo area specifically affects the environment and communities situated downstream.

2. LITERATURE REVIEW

2.1 Introduction

The Autonomous Region of Bougainville (AROB), a resource-rich province in Papua New Guinea (PNG), has a long history of alluvial mining, with practices deeply ingrained since colonial periods (Suwamaru, 2019). While the precise origins of small-scale mining in Bougainville are not officially recorded, it is believed to have intensified around the 1990s following the closure of the Panguna Mine, suggesting its emergence as a post-crisis livelihood strategy. This literature review synthesizes existing knowledge on the impacts of small-scale mining in PNG, specifically focusing on arguments relevant to soil sedimentation.

Despite numerous studies assessing small-scale mining impacts in PNG, the primary focus has often been on recognized mining areas in specific provinces. However, unregistered operations are widespread across the country, with a 2011 survey by Mek estimating over 43,000 grassroots individuals actively engaged in mining across 17 provinces. While small-scale mining serves as a significant source of livelihood, offering an alternative to traditional agricultural pursuits like cocoa and coconut farming (Bainton et al., 2020), its economic benefits are often overshadowed by severe environmental consequences, particularly those related to soil sedimentation.

2.2 Environmental Impacts

The environmental impacts of small-scale mining are multiple and severe, notably including deforestation, destruction of natural vegetation, exposure of topsoil, and subsequent soil erosion. Javia and Siop (2010) highlight these risks, underscoring the detrimental effects of unregulated mining practices on the environment and local ecosystems. These impacts are frequently exacerbated by miners' lack of awareness and disregard for proper environmental management. Previous studies have also noted the careless handling of toxic chemicals such as mercury by miners within PNG (Bainton et al., 2020), a practice often linked to the physical disruption of land and water bodies that contributes to sedimentation. The environmental contamination and social disruptions arising from small-scale mining are widespread, with various provinces experiencing severe effects; for instance, water contamination and habitat degradation in Sepik Province.

2.3 Water Contamination and Sedimentation

The widespread use of mercury for gold extraction by alluvial miners in PNG significantly contributes to the degradation of water bodies, leading to river and water pollution. Javia and Siop (2010) reported that approximately 80%-90% of small-scale miners utilize mercury across alluvial and hard rock sites. Romulus Masiu (2021) reported complaints from communities in central Bougainville regarding mercury contamination of their waterbodies, which was later confirmed by a NARI water quality assessment in 2023. This assessment revealed alarming levels of mercury contamination in the Bovo and Tupukas Rivers, originating from alluvial mining operations upstream. While mercury represents chemical contamination, the physical disruption of riverbeds and banks during mining, often associated with mercury use, directly causes the release of vast amounts of sediment. This leads to persistent turbidity and the physical alteration of river systems, impacting both water quality and aquatic habitats.

2.4 Regulatory Gaps and Environmental Degradation

A significant concern is that many small-scale mining operations function without proper registration and fail to adhere to national mining policies. Javia and Siop (2010) point to a lack of specific legislation governing the small-scale mining sector in PNG, unlike in other countries with similar activities. This regulatory void contributes to the proliferation of unregulated mining activities, which directly exacerbates environmental degradation, including widespread soil erosion and sedimentation. Despite some estimates of registered miners (Mek, 2011), the undocumented operations pose a substantial challenge to effective environmental management and control of sedimentation impacts.

3. METHODOLOGY

The study was carried out in the small-scale mining communities in Atamo, Eivo-Torau one of the Constituency in the Panguna District, Autonomous Region of Bougainville, PNG. Atamo is located 6° 15' S (Longitude) and 155° 26' E (Latitude) with an elevation of 1,000 masl (Figure 2)

The population of the people in this area is about 8,000. Major socio-economic or livelihood activities in the area include farming, petty trading, teaching, pmv operation and small-scale gold mining. Majority of the people are engaged in small scale mining and farming which includes selling food stuffs. This place is well known for its quantity and quality gold production from small scale mining.

The study employed a qualitative approach through field surveys and active observation to explore the impact of soil sedimentation to downstream communities. Primary data was gathered via direct observation and taking photograph as well as in-depth interviews with 20 key informants (teachers, chiefs) and structured questionnaires administered to 10 community elders and 10 primary teachers. Secondary data was obtained from existing literature on small-scale mining in PNG and other developing countries. This approach allows for in-depth understanding and interpretation of the experiences, perceptions, and perspectives of individuals and communities affected by mining activities.



Figure 2. Map showing active Small scale mining in Atamo area. Source: Google LLC. (2025).Google Earth [software].Retrieved from <https://www.google.com/earth/>

4. RESULTS AND DISCUSSION

The observations in the Atamo area revealed significant and pervasive impacts directly attributable to soil sedimentation originating from upstream small-scale alluvial gold mining sites. These impacts manifest in several critical ways affecting the environment and downstream communities.

4.1 Deterioration of Water Quality

The continuous influx of sediment has severely compromised water quality, rendering it perpetually turbid and dirty (Biri et al., 2024). This constant murkiness indicates a high suspended sediment load, which is a direct consequence of inadequate erosion control at mining sites. Such chronic turbidity reduces light penetration into the water column, impacting aquatic plant life and the overall health of the river ecosystem (Divine Word University, 2018). Similar problems are widely reported in other developing countries, where artisanal and small-scale gold mining significantly increases turbidity and suspended solids, making rivers unsuitable for consumption and devastating aquatic ecosystems (Muringaniza et al., 2022). For instance, studies in Zimbabwe and Ghana have consistently shown that unregulated mining activities lead to substantial increases in these parameters, severely degrading water quality (Macdonald et al., 2015).



Figure 3. A river showing highly turbid and dirty water, affected by soil sedimentation residue from mining activities

4.2 Impact on Marine Life

The excessive soil sedimentation has had a devastating effect on aquatic life within the affected waterways (Biri et al., 2024). Downstream communities reported a drastic decline in fish populations, with some lamenting that

the river is now "nothing" (Biri et al., 2024). This significant reduction in aquatic biodiversity is primarily attributed to habitat degradation caused by pervasive sediment deposition, which smothers crucial spawning grounds, alters benthic environments, and disrupts the delicate aquatic food chain. Furthermore, high sediment loads can directly harm fish gills, further contributing to their diminished populations (Divine Word University, 2018). Similar pervasive issues are observed in other contexts, where mining-induced sedimentation alters aquatic habitats and leads to significant declines in fish and invertebrate populations (Masocha et al., 2019). For instance, numerous studies highlight how elevated suspended sediment concentrations can cause direct harm to fish gills, reduce growth rates, and severely impact spawning success, ultimately leading to shifts in community structure and population size (Muringaniza et al., 2022).

4.3 Damage to Infrastructure

The accumulation of soil sediment has significantly impacted local infrastructure, most notably the road network (see figure 4 A.). The road connecting various communities in Atamo, originally constructed to follow natural water flow patterns, has visibly deteriorated and broken in sections due to altered hydrology and water raise caused by sediment build-up (see figure 4.B). This poses considerable logistical challenges and safety concerns for local residents, disrupting their mobility and access to essential services.



Figure 4. a) Ariel View of disrupted water flow pattern; b) Road affected due to water flow disturbance; c) Road affected due to sedimentation

4.4 Alteration of River Flow Patterns

The soil sedimentation has directly caused the backflow of water and significantly altered the normal running river ways. Sediment deposition has led to a reduction in river channel capacity, forcing the water to seek new

paths and creating new, often unstable, water running flows. This disruption to the natural hydrology of the river system not only exacerbates flooding in certain areas but also prevents the river from following its historical course, impacting traditional land use patterns and potentially causing further erosion in newly formed channels. This situation aligns with observations in other mining regions where sediment accumulation causes problems with water flow and contributes to environmental degradation (ResearchGate, 2003; AJOL, 2018).



Figure 5. River flow pattern disrupts by continuous soil accumulation at bottom

5. CONCLUSION

The examination of small-scale alluvial gold mining in the Atamo area has unequivocally demonstrated that soil sedimentation poses a profound and multi-layered threat to both environmental integrity and community well-being. While small-scale mining provides vital income opportunities for local populations, the uncontrolled nature of these activities leads to severe environmental consequences, specifically evidenced by the pervasive impacts of sedimentation. The degradation of water quality, the decimation of aquatic ecosystems, the damage to crucial infrastructure, and the irreversible alteration of natural river courses collectively highlight an urgent need for intervention. Similar pattern of environment degradation and socio-economic challenges have been observed across the developing countries due to unregulated alluvial gold mining activities. Countries like Zimbabwe and Ghana reported degradation of water quality due to elevated turbidity and suspension of solids resulting to disrupts of natural water flows (Muringaniza et al., 2022 Masocha et al., 2019).

These findings reinforce that the problem of sedimentation from artisanal mining is not unique to Atamo but is a widespread challenge in many regions where such activities occur, often exacerbated by a lack of awareness, inadequate regulation, and limited implementation of mitigation strategies. Addressing these issues requires a comprehensive and integrated approach, emphasizing the critical importance of effective erosion control measures, the restoration of affected habitats, and the establishment of robust policy frameworks. Ultimately, safeguarding the long-term ecological health of the rivers and ensuring the sustainable well-being of downstream communities necessitates a balance between economic development and stringent environmental stewardship.

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